Can we use benthic invertebrate communities to monitor the effects of dredging activities on navigated rivers?

Pouvons-nous utiliser les communautés d'invertébrés dans le suivi des effets d'opérations de dragages sur les voies navigables ?

Nadège L. Galéa[1] ; Amélie A. Charnoz[1] ; Alexis P. Guilpart[1]

[1]Centre d'études et d'expertises sur les risques, l'environnement, la mobilité et l'aménagement. Département Ville Durable, Unité Nature et biodiversité, 12 rue Léon Teisserenc de Bort 78190 Trappes-en-Yvelines. (Corresponding author: alexis.guilpart@cerema.fr)

RÉSUMÉ

L'usage important des masses d'eau a des conséquences sur les écosystèmes aquatiques. Dans le cas des voies navigables, le besoin d'entretiens des chenaux, en particuliers les opérations de dragages pourraient impacter fortement les communautés. Les habitats et organismes vivants peuvent être affectés ou modifiés par la baisse de la concentration en oxygène dissout et l'augmentation de la turbidité causés par la remise en suspension de sédiments. Nous avons mené une étude sur différents sites de navigation du bassin de la Seine où des opérations de dragages ont lieu chaque année. Nous avons échantillonné et comparé des communautés d'invertébrés benthiques avant et après des opérations dans le but d'étudier leurs compositions taxonomiques et fonctionnelles et l'usage potentiel d'indices biotiques et d'indicateurs dans les suivis de ce type de perturbation. Les organismes à court cycle de vie semblent être favorisés à la suite d'une opération de dragage. De plus, nous avons pu observer une augmentation des populations de *Chelicorophium curviuspinum* sur certains sites après ces opérations. Nos résultats suggèrent que les impacts des dragages sur les communautés benthiques restent très limités et complexes à étudier.

ABSTRACT

The massive use of freshwater bodies have consequences on aquatic ecosystems. For the waterways, the need for maintenance of river chanel, especially regarding dredging operations could strongly affect aquatic communities. Through the local decrease of oxygen concentration in the water column and the increase in turbidity caused by sediment resuspension, habitats and living organisms can be altered or modified. We conducted a study on different navigated sites of the Seine watershed were dredging operations occured every year. We sampled and compared benthic invertebrate communities before and after the operations, in order to study the taxonomic and functionnal composition of the communities and the possible use of biotic indice and indicators to monitor this pressure. Short life cycle organisms appear to be favored at the end of the dredging operation. Furthermore, we saw a raise of *Chelicorophium curviuspinum* population after dredging operation. Our results suggest that the impacts of dredging operations on benthic communities are very limited and seems very complex to study.

MOTS CLES

Anthropogenic pressure, bioindicators, Chelicorophium curvispinum, Seine watershed, waterway

1 INTRODUCTION

With an increase reaching +40 % in twenty years, waterways navigation tends to become stable in France around 53 millions metric tons of merchandise transported per year. This success can be explained through its reliability, its low cost as well as its low carbon emissions. However, the massive use of the rivers by transport activities can strongly affect the physical, chemical and biological status of these ecosystems. Changes in flow velocities, resuspension of sediments, and bank erosion caused by barge traffic can impair the overall ecosystem (Pham Van Bang *et al.*, 2009). The use of waterways induces a need for maintenance including dredging operations to guarantee a minimal depth of the river channel. These operations result in resuspension of sediments and any toxic substances they may contain as well as a decrease of dissolved oxygen concentrations. These pressures can affect living organisms and habitats on the dredged site and downstream.

As a European Union member, France agree to the aim of the Water Framework Directive and then must act to achieve the good ecological and chemical status of water bodies. This is why dredging operations, even small ones like maintenance operations, have to be allowed and monitored by state water police services. However, the specific ecological consequences of maintenance dredging activities in rivers and the methodology to study them are poorly documented. Our study were conducted to assess two questions :

- Which modifications can be observed in benthic invertebrate communities exposed to a dredging operation ?
- Can we use common ecological indicators and biological index or functionnal traits to monitor the effects of a dredging operation ?

2 MATERIALS AND METHODS

2.1 Site locations

Our study were conducted between 2015 and 2017 on 5 different navigated sites of the Seine watershed (Center and North of France), where dredging operations occured usually every year with mechanical dredger. These sites tends to respresent the different contexts (river discharge, operation duration, natural or constructed bank, etc.) which can be encountered by the waterways operator, « Voie Navigables de France » (VNF).

Table 1 : sites, river contexts and operation sizes.

Site name (City) and department number	Janville (60)	Moisson (78)	L'Isle-Adam (95)	Migennes (89)	Courcy (51)
River name	Oise	Seine	Oise	Yonne	Bief de Courcy
Mean annual discharge (m^3/s)	34,10	280,11	88,71	86	Irrelevant (canal)
Type of bank	±Constructed	±Natural	Constructed	Natural	Constructed
Type of sediment	Silt	Sand and silt	Silt	Sand	Sand and silt
Dredging operation duration	~3 weeks	~7 days	~7 days	~8 days	~7 days

2.2 Sampling protocol

Every site was sampled on two stations : one « upstream station », located upstream the operation, and was assumed to be non-impacted by the dredging activities and could be used as a reference.

One « downstream station » located just downstream the operation. These two stations were sampled around one week before the operation and one month after the operation and then around one year after the operation in order to investigate potential resilience or persistence phenomena on the communities. 12 samples corresponding to diverse micro-habitats were collected on each station at every campaign, distributed on river bank, river channel and the transitional zone.

Samples were frozen and analyzed at the lab : invertebrates were counted and identified at the genus level (excepted for Oligochaeta and some diptera taxa) using a stereo-microscope.

2.3 Data analysis

Taxonomic lists were transformed in functional-trait-based list in order to build functionnal communities through a fuzzy-codding method. Shannon index and IBG-A (French biotic index adapted to big rivers) were calculated as well as % of different taxonomic or functional groups (eg. %OC = % of Oligochaeta+Chironomidae, % of scrapers-feeders, etc.).

3 RESULTS AND DISCUSSION

3.1 Common Indicators and biological indices

Taxa diversity, Shannon index, IBG-A and % of taxonomic groups did not show any clear and significant tendencies after the dredging operation. Even if these parameters increase or decrease, the upstream stations tends to present the same range of variations.

3.2 Functional traits

Short life cycle organisms appear to be favored at the end of the dredging operation, even if our statistical outlet present unsatisfying repartition of residuals, which prevent us to conclude on this result. However, it would be consistent that short life cycle organisms would be the less affected by a temporary anthropic pressure such as a dredging operation. Buendia *et al*. (2012), showed that short life cycle and small size allow a good persistence when the proportion of fine sediment is high. Traits like feeding habits or size did not show any significant variations which could be connected to the perturbation. Sensitive groups like scraper-feeders or shredders-feeders would have been affected by the resuspension of fine sediment. However, this response is more encountered in cases where fine sediment is released with high nutrient concentrations (Von Bertrab *et al*., 2012), which was not the case in our study.

3.3 Invasive taxa and the case of *Chelicorophium curviuspinum*

Our results did not show any significant increase of the total invasive taxa. However, one species, *Chelicorophium curviuspinum*, significantly increased one month after the operation on the two downstream sites of Oise river : Janville (Wilcoxon-Mann-Whitney Test, p-value = 0,03) and l'Isle-Adam (Wilcoxon-Mann-Whitney Test, p-value = 0,04).

4 CONCLUSION

Our study highlights how complexes are the investigation on the ecological consequences of dredging operations on big rivers. Each river seems to present specific responses and it is difficult to draw general trends. Moreover, common indicators are irrelevant to detect any impact. There is a need to conduct more studies and develop adapted indicators, more likely to be based on functionnal traits (even if, at this time, our functionnal communities presented few consistant changes). Another feature of our studied ecosystems is that their benthic communities are long-time exposed to dredging activities and other pressures linked to the navigation. We can hypothesize that living communities are structured and adapted to this anthropic pressures and do not present visible changes when they occur.

LIST OF REFERENCES

Buendia, C., Gibbins, C.N., Vericat, D., Batalla, R.J., Douglas, A. (2012). Detecting the structural and functional impacts of fine sediment on stream invertebrates. *Ecological Indicators*, 25, 184-196

Van Bang, D. P., Ouahsine, A., Sergent, P., Long, B., Montreuil, S., Debaillon, P., & Hissel, F. (2009). Vagues et érosion des sédiments générées par le passage des bateaux de navigation intérieure, mesures in situ et analyses. *Revue Technique Maritime et Fluviale*, *2*, 18-24.

Von Bertrab, M. G., Krein, A., Stendera, S., Thielen, F., & Hering, D. (2013). Is fine sediment deposition a main driver for the composition of benthic macroinvertebrate assemblages?. *Ecological indicators*, *24*, 589-598.